Physics Five-Year Academic Plan for 2002-2007

January 4, 2002

The Physics Department presents the following five-year rolling academic plan with a sense of excitement and urgency. The expected enrollment growth of the campus during the next 10 years, especially in the COE, significantly impacts the Physics Department and represents a singular opportunity and defining period for the Department to achieve its programmatic goals. We will provide the justification and strategy for achieving a top-flight department with highly distinguished and balanced research programs in two broad core physics disciplines. These are condensed matter physics and high-energy physics/astrophysics. This will require two indispensable elements: a nucleus of senior experimental and theoretical faculty of the highest distinction in core disciplines, and large, strongly funded, and highly visible experimental programs in selected areas such as Nanoscale Materials Science. To insure a prominent position in these developing areas, we intend to recruit top-level faculty including members of the National Academy of Sciences and with other distinctive awards such as the APS Buckley Prize or Panofsky Prize. We are well on our way to accomplishing these goals with the recent TOP hire (Panofsky Prize Recipient) and current TOP recruitment (Member of the National Academy of Sciences).

Condensed Matter Physics

In our previous academic plan we envisioned the condensed matter program with 2 focused groups in surface physics and correlated electron physics evolving into 2 focused groups on nanoscale physics and complex adaptive matter. Presently, we are successfully transforming our research into these new target areas. One senior experimentalist (Mills) and one junior theorist (Pryadko) were just hired in the growth areas pursued by the Department. Our nanoscale physics program is being developed with strong involvement with the Center of Nanoscience and Technology that was established in 2000, under the direction of Robert Haddon. The complex adaptive matter program is being developed in collaboration with Los Alamos National Laboratory under the guise of a new UC multi-campus research program (MRP) which is due to be established by mid 2002 with UCOP and Chancellor support. The multi-departmental graduate research program in Environmental Physics and ties previously established between Condensed Matter Physics and the Environmental Science Department continues to thrive. The Environmental Physics program is part of the Environmental Science Graduate Research Unit (GRU). Two $10 M multi-disciplinary multi-investigator proposals for NSF Environmental Molecular Science Institutes were submitted. We have also submitted two NIRT proposals, totaling $4M, in bio-related research. Finally, a new multi-disciplinary initiative in biomolecule-mineral interactions is planned for submission in 2001-2002.

Worldwide, condensed matter physics has played an indispensable role in the understanding and development of new materials including semiconductor, optical, and magnetic materials at the heart of current information and telecommunications technology. Condensed matter physics is now moving toward tackling new problems: the manipulation of materials at the atomic level, the assembly of nanoscale functional units and the rigorous understanding of highly complex interacting systems. Research in these areas will lead to unprecedented understanding and control of materials which will impact not only the existing physics research community and current industries but also lead to new scientific opportunities in biology, chemistry, environmental science and new technologies. This view is what motivates billion dollar research initiatives at the state and federal level emphasizing nanoscale science and engineering.

We envision condensed matter physics playing a central and leadership role in future UCR-wide material science and technology research. Our current faculty and those we would hire will collectively develop new experimental techniques for probing, manipulating, and fabricating new materials, and new theoretical approaches to understanding novel material systems. This research will form the base upon which multi-investigator and multidisciplinary research centers involving nanoscale physics, chemical physics, environmental physics, biophysics and related engineering are built.

As a long-range plan over the next decade, the UCR condensed matter physics program needs to grow to 24 faculty (18 experimentalists and 6 theorists in a 3:1 ratio). While there will be strong overlap, the faculty will be organized into 3 subgroups with approximately 8 faculty in each group emphasizing:

- *Nanoscale physics:* the properties that result from the manipulation of matter and the investigation of properties at the nanometer length scale with an emphasis on understanding the functionalities of individual particles.

- *Hybrid systems:* the physics of new materials that result from combining magnetic, optical, electronic, mechanical, chemical or biological properties, sometimes under restricted geometries to make new functionalities. An important example is *spintronics* where instead of the electric charge, the spin degrees-of-freedom of the electron are exploited in new practical devices.

- *Complex adaptive materials:* the physics of correlated, cooperative, or emergent phenomena that occurs on either multiple length scales and/or multiple energy scales. An important concept in this area is self-organized order and functionality in complex systems. This subfield can be further divided into biophysics/bio-informatics and inorganic complex systems. The biophysics/bio-informatics area will concentrate on the physical properties of biomaterials (e.g., electron dynamics), interactions between bio-molecules and solids, encoding of information, molecular recognition and self-assembly. There is now speculation that certain fundamental principles relevant to many biomaterials may also be operative in some complex inorganic systems, especially those where correlated-electron phenomena are prevalent.

Each of these areas overlie other campus units including Chemistry, Biology, Environmental Sciences, various departments in COE and the Center for Nanoscience and Technology. Although such growth would be optimal if developed in a coordinated fashion with other campus units, our emphasis is on the fundamental physical properties of novel systems and therefore our efforts are distinct enough to be developed independently.

Our current faculty are already aligned with several of these areas. Under nanoscale physics, Mohideen is measuring the Casimir force between metal surfaces separated by a few nanometers, Yarmoff is studying metal and semiconductor quantum dots and Tom is studying electron-phonon coupling at surfaces. Under hybrid systems, Mills (experiment) and Pryadko (theory) are studying 2-d electron gas physics in layered semiconductor materials; Tom and Yarmoff are engaged in environmental physics research involving mixed bio-organic-liquid-solid interactions. Under molecular biophysics/biocomputing, Beyermann is studying transport in DNA, Mohideen is measuring the force between 2 protein molecules using atomic force microscopy, and Mills is working on DNA computing. Under complex adaptive materials, Beyermann, MacLaughlin, Pryadko, and Mills study correlated electron systems.

High-Energy Physics

The ultimate aim in high-energy physics is to determine the basic building blocks of matter and to understand the interactions between them through a single underlying theoretical description. The investigation covers a wide area, from accelerator physics at large international laboratories involving the collisions of elementary particles or heavy ions, to detection of neutrinos and cosmic radiation from outer space, and probes of the far distances of the universe for further evidence of the Big Bang. The UCR physics department currently has programs in three broad areas: Elementary Particle Physics (Experiment: Clare, Ellison, Gary, Hanson, Shen, VanDalen and Wimpenny; Theory: Desai, Ma and Wudka), Relativistic Heavy Ion Physics (Experiment: Barish and Seto), and Astrophysics/Astroparticle Physics (Shen, Zank and Zych).

In order to achieve our goal as a premier research university in high-energy physics, we must play a leading role in addressing the most fundamental issues in the field. We believe a total of approximately 24 faculty are needed pursuing the topics listed below, which represent the most important questions in this branch of physics.

- *CP Violation*: Why is our universe matter-dominated? How is CP symmetry violated? CP violation - a small deviation in Nature's otherwise symmetric order – has been observed for several decades. Yet, the origin of CP violation remains a mystery. It is one of the most fundamental questions in particle physics today. The phenomenon of CP violation also has cosmic consequences; in particular, it plays a crucial role in the formation of our universe. CP violation can best be studied in the decays of *b*-quarks, and two B-factories (asymmetric e+e- ring accelerators) have now been built for this purpose. One is in California and the other is in Japan. Beginning in 2002, the UCR HEP group will participate in the BaBar experiment at PEP II, the B-factory at SLAC.

- *Neutrino Properties*: Does the neutrino have mass? Are there more than three generations of neutrinos? What causes the solar neutrino deficit? These questions would be investigated in various experiments studying neutrino oscillations with neutrinos from accelerators, reactors and the sun. UCR is part of the MiniBooNE experiment at FNAL, approved to run in the early 2000s. UCR can be a leader in this field if we build on our strength and expand to make major contributions in one of the leading experiments such as MINOS, SNO, SuperKamiokande and, potentially, SJ NUSL.

- *Higgs Boson and Grand Unification*: What gives particles mass? Is super symmetry the answer to the next step in unification? Are there more than three families of quarks and leptons? The best limits on the mass of the Higgs boson have been obtained at CERN and FNAL. UCR is a founding member of the CMS collaboration at the Large Hadron Collider (LHC) at CERN. We believe that with the large increase in energy we will discover the Higgs boson soon after LHC begins operation in 2007-08. Grand unification theories (GUT) predict the existence of new particle at a mass scale of approximately 100 GeV. The LHC will provide the opportunity to obtain experimental information critical to the formulation of these theories.

- *Physics Beyond the Standard Model*: Even though the Standard Model has enjoyed considerable success in describing existing experimental data, the theory is incomplete and inadequate. Major accelerator initiatives in the U.S. and elsewhere are intended to provide experimental breakthroughs to guide the community out of this impasse. Under consideration is the "Next Linear Collider" (NLC) with electrons and positrons colliding at 1.5 TeV. It is important for UCR to be a significant partner in the next collider from the beginning. We envision the hiring of physicists with established records in collider design to participate in the building of the NLC and in the subsequent physics program. Gail Hanson will lead the UCR effort as Director of the new Center for Accelerator Physics at UCR.

- *Quantum Chromodynamics in Bulk Matter*: Of the basic interactions, the strong interaction is the least understood. High-energy heavy ion collision experiments provide the ideal laboratory for the study of strong-interaction physics. These collisions create an environment of unprecedented high pressure and high energy density, in which the properties of the primordial quark-gluon plasma can be studied. While RHIC gives us the first opportunity, the heavy-ion phase of the LHC with a thirty-fold increase in energy will enable us to measure a full range of observables to probe the primordial state of the system. We believe that UCR will be a world leader in this field if we can build on our existing strengths.

- *Astrophysics/Astroparticle Physics*: Astroparticle physics and high-energy astrophysics have emerged as exciting field of physics during the past with the discovery of blazers capable of TeV emissions. New projects such as the GLAST space mission and the ground-based VERITAS and Solar-2 observatories to study point sources emitting high-energy gamma rays, and the Ice Cube to search for sources by detecting the high-energy neutrinos emitted. UCR has a long history in the study of gamma ray astrophysics and astroparticle physics. With the arrival of Prof. Zank we now have broad program in space plasma physics and theoretical astrophysics. This includes the study of the solar corona and solar wind acceleration, the interaction of the solar wind with comets, turbulence, particle acceleration and transport in the interplanetary medium, and the interaction of the heliosphere with the LISM and its global structure. In astrophysics this includes shock cosmic ray particle acceleration in supernova remnants (SNRs) and the associated gamma-ray production.

- *Theory*: The experimental high-energy physics community will be accumulating precision data and making accurate observations at an unprecedented rate in the coming decade. This, in turn, will generate increasing demands for the theoretical analysis of data and the interpretation of the results. Does the Higgs boson exist? Is Supersymmetry valid? What is responsible for CP violation? Where do we go in the unification of the interactions? How do we explain the bizarre mass structure of the quarks, leptons, and neutrinos? If history is any guide, just when we think we have solved the main problems, new ones emerge giving birth to entirely new theories. For UCR to become one of the top research universities in high-energy physics, we must build a first rate theory group by recruiting senior and junior faculty in theoretical nuclear physics, particle physics, and cosmology.

Physics Department Growth

During the next decade, we foresee an eventual total of 24 FTE faculty members in condensed matter, consisting of 18 experimentalists and 6 theorists. Each of the three subgroups identified above will have approximately 8 participating faculty. This requires the addition of 15 new FTE. In high-energy physics and astrophysics we need 24 FTE for the balanced program described above. This requires an addition 11 FTE in high-energy/astrophysics. The total number of new hires for the department is 26.

This plan calls for the aggressive recruitment of new physics faculty at a rate that is unprecedented in the recent history of the department. Both top quality senior and junior faculty must be recruited with the goal of developing selective emerging fields of physics that will represent the cutting edge in ten years. We have identified these areas in our plan. The development of clusters of research expertise requires a long-term focus by the department and commitment by the administration.

Before addressing programmatic hiring needs for 2002 and beyond it is well to review our plan for filling FTE already allocated. Positions are indicated by allocation year when the searches will be initiated.

A. Existing Positions

Academic Year 2001-2002

1. *Open-Level Position in Condensed Matter Theory: This is a continuing search. It is necessary and urgent to build up our program in condensed matter theory. The hire will be in any sub-field that broadly supports our existing experimental programs.*

2. *Target-of-Opportunity Position in Astrophysics: The Physics Department and IGPP are jointly pursuing a very senior candidate in theoretical cosmic ray astrophysics. This will be a joint appointment in physics and the IGPP. It will strengthen our new initiative in astrophysical theory. Part of the astrophysics replacement position is being used for this TOP appointment.*

Academic Year 2002-2003

1. *Position in Astrophysics: The Physics Department and IGPP will jointly pursue a new hire in astrophysics to build on the strengths already existing in physics and the IGPP. Part of the astrophysics replacement position is being used for this TOP appointment.*

2. *Position in Condensed Matter Theory: This is a replacement position. It is essential to build up our program to a minimum critical mass in condensed matter theory. The hire will be in any sub-field that broadly supports our existing experimental programs.*

B. New Positions

Year 0: 2001-2002

A. *Open Position in Condensed Matter Experiment: This search is being undertaken by CNAS to support the Center for Nanoscience and Technology.*

Year 1: 2002-2003

1. *Open Position in Condensed Matter Experiment: Hybrid magnetic, optical and electronic materials, e.g., spintronics, photonics.*

2. *Tenure-Track Position in Condensed Matter Experiment: Nanophysics.*

3. *Tenure-Track Position High Energy Experiment: e+e- collider physics at SLAC (BaBar).*

Year 2: 2003-2004

1. *Open Position in High Energy Experiment: Accelerator Physics in support of the Center for High Energy Physics (Hanson).*

2. *Tenure-Track Position in Condensed Matter Experiment: Novel device geometry physics, e.g., single electron devices, quantum dot/well interactions, polymer/organic hybrid devices.*

3. *Open Position in Condensed Matter Experiment: Biophysics & Biocomputing, Biomolecule-solid interactions.*

4. *Tenure-Track Position in High Energy Theory: Nuclear and Heavy Ion theory*

in the areas of Quantum Chromodynamics and Chiral. This will support the experimental efforts in heavy ion physics.

Year 3: 2004-2005

1. *Tenure-Track Position in Condensed Matter Experiment: Biophysics & Biocomputing, Physical properties of single biomolecule dynamics.*

2. *Tenure-track Position in Condensed Matter Theory: Nanoscale physics, hybrid systems or complex adaptive materials.*

3. *Position in Heavy Ion Experiment: With RHIC at BNL and LHC at CERN, heavy ion accelerator physics will be at the forefront of nuclear physics.*

Year 4: 2005-2006

1. *Position in Condensed Matter Experiment: Biophysics & Biocomputing, Physical properties of complex biological systems (self-induced order or complex adaptive behavior in biological systems) including information theory/computing.*

2. *Position in Condensed Matter Experiment: Nanoscale Physics*

3. *Position in High Energy Experiment: Non-accelerator or astroparticle physics (Hansom commitment).*

Year 5: 2006-2007

1. *Position in Condensed Matter Experiment: Nanoscale Physics*

2. *Position in Condensed Matter Experiment: Nanoscale Physics*

The first five prioritized experimental condensed matter positions are directly aligned with the current vision of CNSE in nanoscience and technology emphasizing carbon, silicon, and biological materials. A general advertisement for positions available at UCR coordinated through CNSE due to appear in Physics Today in Jan. 2002 lists specific target areas: "Applications are encouraged from candidates in the areas of spintronics, nanofabrication of electronic and photonic devices, and atomic and molecular scale manipulation and measurement."

The prioritized positions in high-energy physics and astrophysics are needed to give UCR the strength to become leaders in the most important areas of research in the coming decade.

The key to achieving our academic goals is to aggressively recruit new faculty starting now. These goals can only be obtained with a much larger department. The uncertainties and delays associated with the recruiting process dictate that we jump-start the hiring schedule with a sufficient number of new positions now. A large number of new searches need to be at the open level to attract prominent new faculty to build the new core programs. Positions also need to be allocated in a way that will allow for multiple hiring in the core areas. With these principles as a guide we are pleased to present the above five-year rolling academic plan that is consistent with our long-term goals.

C. Retirements in 2002-2007

At this time no faculty members have indicated that they plan to retire in the next five years. However, it is possible that up to three faculty members (1 in CME, 1 in HEP and 1 in HEA) may decide to retire in this period. These individuals are currently involved in growing fields of the department and there replacements should be in the same general field.

D. Space

Research Lab Space Until 2005

Over the next decade 16,000-18,000 asf of high-quality research space will be needed to accommodate the anticipated growth of the Department. Most of this space will be high-quality laboratory space for new condensed matter experimental faculty. Previously we have documented that almost 10,000 asf of additional research space can be made available within the current Physics Building complex. This will require considerable renovation of existing space with a disruptive relocation of the current occupants. With this plan we will be able to accommodate 5-7 new condensed matter experimentalists. Clearly, renovation of Physics 1117 (Plasma Lab) with a second story has the highest priority. Additional research space such as a high-bay low-cost facility for high-energy and astrophysics faculty and temporary office space for graduate students should be considered. The questions on how to best utilize the magnet laboratory site and where the machine shop facilities will be located need to be resolved soon. Finally, space for new theory faculty will be less demanding during this short-term period but can't be overlooked.

Research Lab Space from 2005-2009

After 2005, new physics experimental faculty will need temporary surge space until the Physical Science II (Material Science) building is completed. Our condensed matter experimental faculty members require laboratory space on the ground floor of a building to reduce vibration and electrical noise and below-floor access (e.g., cryostat pits). We seriously recommend that the ground floor of the new Physical Science I Building be reconsidered as "surge" space for new condensed matter physics faculty hired between 2005 and 2009. This will certainly make the job of hiring the highest quality faculty easier during this transition period. Alternately, Pierce Hall may be able to meet this temporary surge space requirement. Most likely, surge space would be located on the 1st floor of Pierce Hall. This may require additional expense in terms of improved vibration isolation. The floor loading capability on the 1st floor of Pierce Hall would also have to be considered carefully. By 2009, space for 3-5 additional condensed matter experimental faculty will be needed. This is estimated at 5,000-10,000 asf in Pierce Hall. Additional research and office space will also be needed future hires in theory and experimental high-energy and astrophysics between now and 2009.

E. Permanent Staff

The following prioritized staff positions have previously been requested for 2001-02

1. Student Affairs Assistant II: 50% for Student Affairs and 50% for Center for High Energy Physics (Hanson).
2. Assistant Administrative Analyst: 100% to assist department Analyst with budgets and other financial activities.
3. Laboratory Coordinator/Lecturer III: Replace faculty in coordinating and supervising teaching laboratories.
4. Staff Research Associate V: Augment open technician provision to support Center for High Energy Physics (Hanson).

F. Permanent Lecturer

We plan to request that one of our current teaching laboratory lecturers be offered a permanent three-year contract, starting in 2002-2003. This person will complete 18 quarters of service during this academic year.

G. Graduate Student Enrollment Goals

The table below outlines our enrollment goals and funding for new graduate students for AY 2002-03 through AY 2006-07. Each year we attempt to recruit the best students. To do this successfully, we need to offer attractive fellowship packages that are competitive with those offered by other universities. The proposed funding scenario provides competitive packages to all qualified applicants. Many of our best students are international students. While initially expensive, they are very cost effective in the long run for both the research mission of the department and ultimately for the long-term health of California's technological enterprise.

One of the critical factors in recruiting students is our ability to make offers at the earliest possible time. We need to make as many offers as is possible during the first round. We strongly recommend an increase from 8 to 40-50 offers during the first round. From our previous experience this increase in first-round offers will not produce an unacceptable risk for the Department or CNAS. This change is also crucial if we are to meet our enrollment goals.

The recruitment packages summarized below include a $12,000 in Year 1, a $4,000 summer stipend after Year 1and a $4,000 supplemental stipend in Year 2. Nonresident tuition is provided for 2 years where needed and fees are provided in Year 1.

Physics Graduate Student Enrollment Goals

Academic Year	New International Ph.D. Students	New Domestic Ph.D. Students	Total New Students	Total Graduate Students	Graduate Student to Faculty Ratio	Cost* Per Int'l Student Years 1-2	Cost* Per Dom. Student Years 1-2
2002-03	10	5	15	51	2.13	$ 48,242	$ 25,353
2003-04	10	5	15	63	2.25	$ 49,463	$ 25,539
2004-05	10	5	15	75	2.42	$ 50,714	$ 25,727
2005-06	10	5	15	84	2.47	$ 51,997	$ 25,915
2006-07	10	5	15	92	2.49	$ 53,313	$ 26,106
*Years 3-5 covered by P.I.-funded GSR appointment.					Totals	$ 2,537,279	$ 643,198
							$ 3,180,478

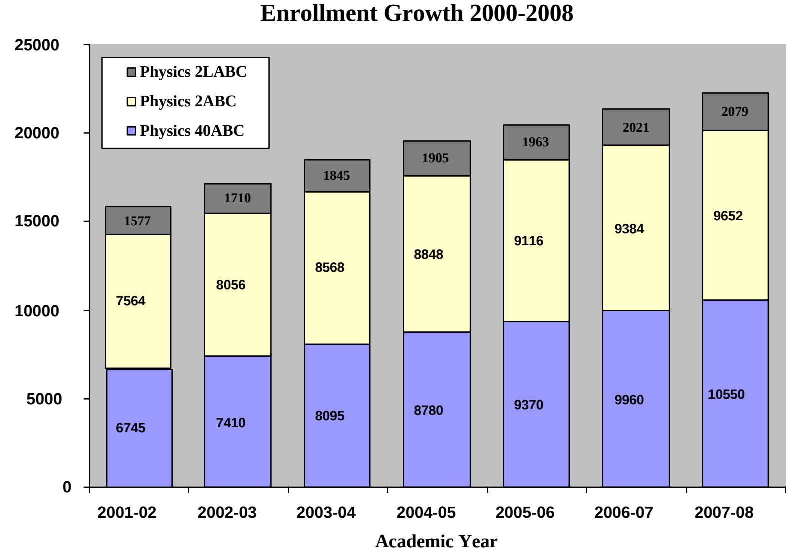
H. Undergraduate Enrollment Goals

As the enrollment of the Campus, CNAS and COE continues to grow we expect the number of applicants for physics majors will continue to grow. A key factor is recruiting these applicants has been the availability of freshman academic fellowships that the physics department offers. The funds for these relatively small grants have come from various small departmental endowments. To continue and expand this successful approach, additional CNAS funds will be needed in the supplement our own funds.

Physics Undergraduate Student Enrollment Goals

Academic Year	Total New Freshmen	Total New Transfers	Total Undergraduate Enrollment	Undergraduate Student to Faculty Ratio	Freshman Academic Fellowships
2002-03	19	10	81	3.38	$ 3,000
2003-04	21	11	91	3.25	$ 3,000
2004-05	24	11	100	3.23	$ 3,500
2005-06	26	12	110	3.23	$ 3,500
2006-07	28	12	120	3.24	$ 4,000
				Total	$17,000

I. Workload and Programmatic Physics FTE Growth



The first chart below is derived from the latest campus projections for enrollment growth. The most significant factor affecting the physics workload is the expected growth in our courses serving the life science and engineering students. These are: Physics 2ABC, 2LABC and 40ABC. An increase in workload for our physics courses for non-science students from CHASS is also expected. We have calculated our total workload and the number of physics faculty FTE from these and other projections, using a 23.0 student-to-faculty ratio. In 2001-02, our workload-driven FTE is at 21.6 while our actual FTE is 23.0. It is only in the last year or so that our actual FTE has caught up to the enrollment-driven FTE. In 2007-08, our teaching load should justify 31.2 FTE. This is shown on the second chart. This chart also shows the FTE growth as outlined in this academic plan. In 2007-08, our plan calls for 39.0 faculty FTE, based on programmatic needs that are described in this document. This is a sizable increase beyond that justified by workload alone. The expected growth of the campus during the next 10 years represents a singular opportunity and defining period for the Physics Department to strive to achieve its programmatic goals for achieving a top-flight department with highly distinguished and balanced research programs in two broad core physics disciplines.